Status Report on $Z \rightarrow \tau\tau$ Measurement

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(for Lepton+Track Working Group)

Outline

- Status of Ingredients: triggers, efficiencies etc.
- Official public plots (APS)
- Backgrounds to Z that were not treated right before – Heavy Flavor
- New approach to backgrounds and Changes in baseline cuts
- Preliminary Results

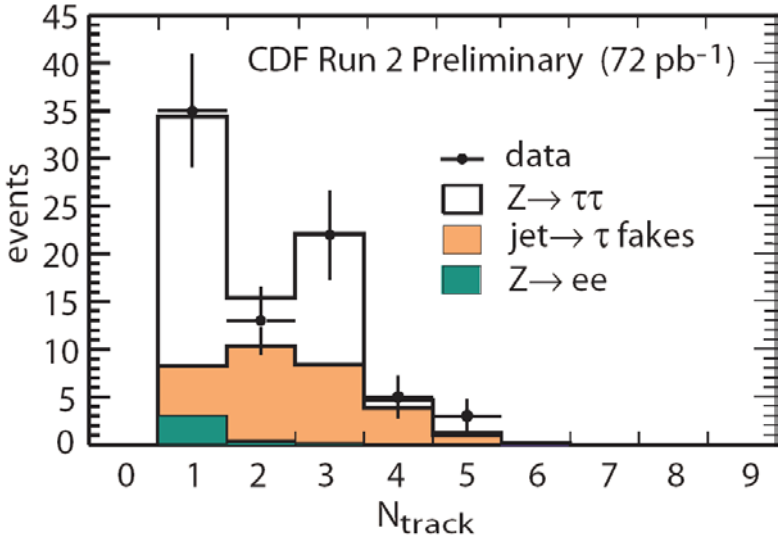
Recent CDF Notes from LT group

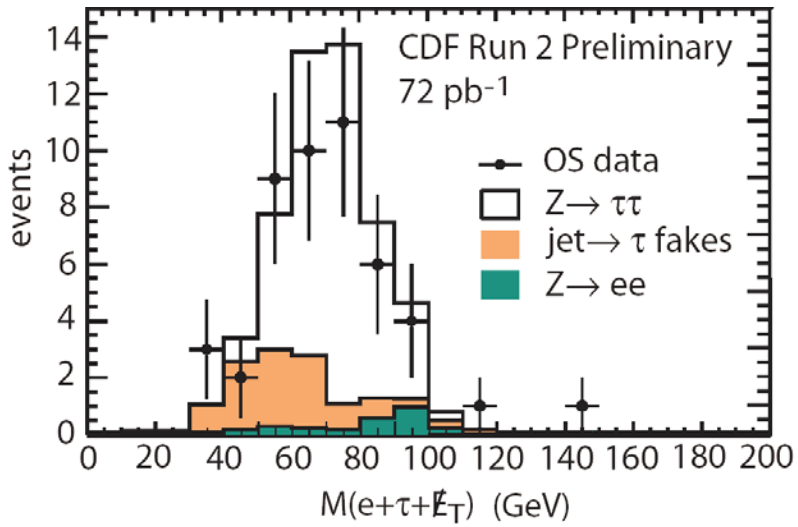
- **Title:** Muon Efficiency for Exotic Lepton Track Trigger
  Author(s): S. Baroiant M. Chertok T. Kamon V. Khotilovich T. Ogawa C. Pagliarone A. Safonov E. Vataga
  CDF Note Number: CDF/ANAL/TRIGGER/CDFR/6358
  Pub. Info: CDF Note
- **Title:** XFT Efficiency of the ISOTRACK leg in lepton+track triggers.
  Author(s): M. Chertok T. Kamon V. Khotilovich D. Toback T. Ogawa A. Safonov
  CDF Note Number: CDF/ANAL/TRIGGER/CDFR/XXXX
  Pub. Info: CDF Note
- **Title:** Extraction of Z->tau tau signal using Run II leptpn + track trigger -Electron Channel-
  Author(s): A. Anastassov, S. Baroiant, M. Chertok, J. Conway, S. Demers, M. Goncharov, D. Jang, T. Kamon, K. Kotelnikov, V. Khotilovich, R. Lander, A. Lath, K. McFarland, P. Murat, T. Ogawa, C. Pagliarone, F. Ratnikov, A. Safonov, A. Savoy-Navarro, J.R. Smith, S. Tourneur, E. Vataga, T. Vaiciulis, Z. Wan
  CDF Note Number: CDF/ANAL/EXOTIC/CDFR/6402
- **Title:** Update on the Lepton + Track Trigger in Run II - Definition and Physics Goals -
  Author(s): A. Savoy-Navarro, T. Ogawa, T. Kamon, M. Chertok, A. Safonov, S. Tourneur
  CDF Note Number: CDF/ANAL/TRIGGER/CDFR/6325
- **Title:** Measurement of Level 3 Trigger Efficiency for 8 GeV Inclusive Electron Trigger Using Conversions
  Author(s): S. Baroiant, M. Chertok, M. Goncharov, T. Kamon, K. Kotelnikov, V. Khotilovich, R. Lander, T. Ogawa, A. Safonov, A. Savoy-Navarro, J.R. Smith, S. Tourneur
  CDF Note Number: CDF/ANAL/TRIGGER/CDFR/6324
- **Title:** Measurement of Electron Trigger Efficiencies for Level1 and Level2 8 GeV Triggers
  Author(s): S. Baroiant M. Chertok M. Goncharov T. Kamon K. Kotelnikov V. Khotilovich R. Lander T. Ogawa A. Safonov A. Savoy-Navarro J.R. Smith S. Tourneur
  CDF Note Number: CDF/ANAL/TRIGGER/CDFR/6257
  Pub. Info: CDF Note

Ingredients

- Trigger Efficiencies:
  - Most of trigger efficiencies are extracted and documented
  - The only missing piece is tau L3 efficiency
- Reconstruction and ID efficiencies:
  - Electrons are almost standard - will extrapolate ETF efficiencies using MC
  - Tau efficiencies – from MC. There are indications that $\pi 0$ reconstruction needs improvements (discussed later).

$Z \rightarrow \tau\tau$ Plots -APS2003



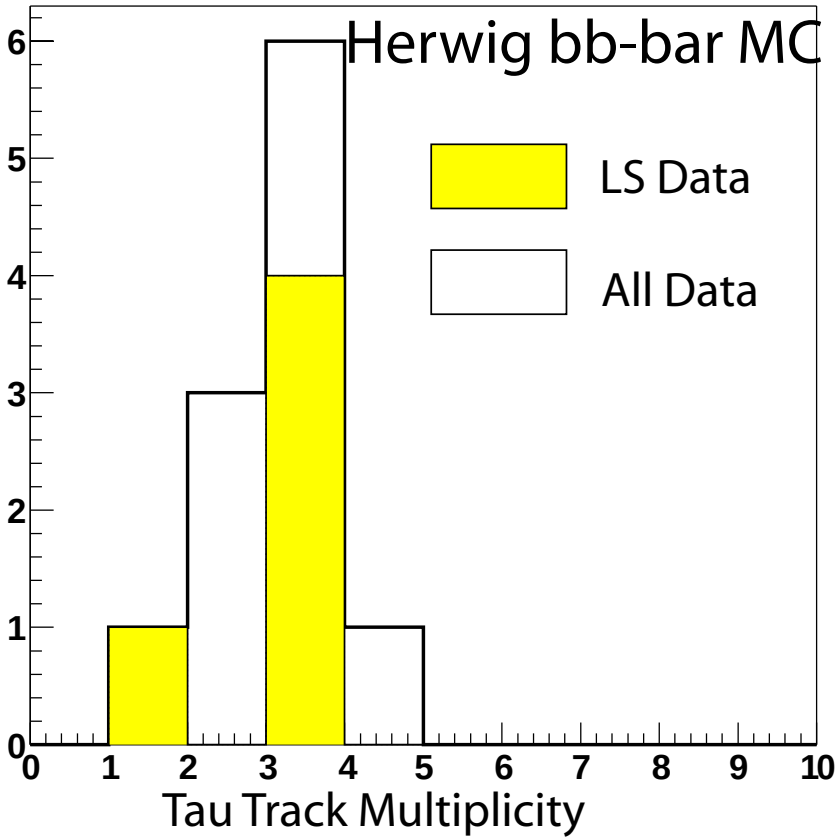


- First public plots
- Shape of QCD backgrounds from Tau Group fake rates
- Fit for the x-section roughly agrees with 240-270 pb Z cross-section
- Unanswered questions:
  - Strange OS/LS balance
  - X-sections based on mass and multiplicity are 40% different
  - Problems even worse if tau PT cut is less than 20 GeV

What Can We Do Then?

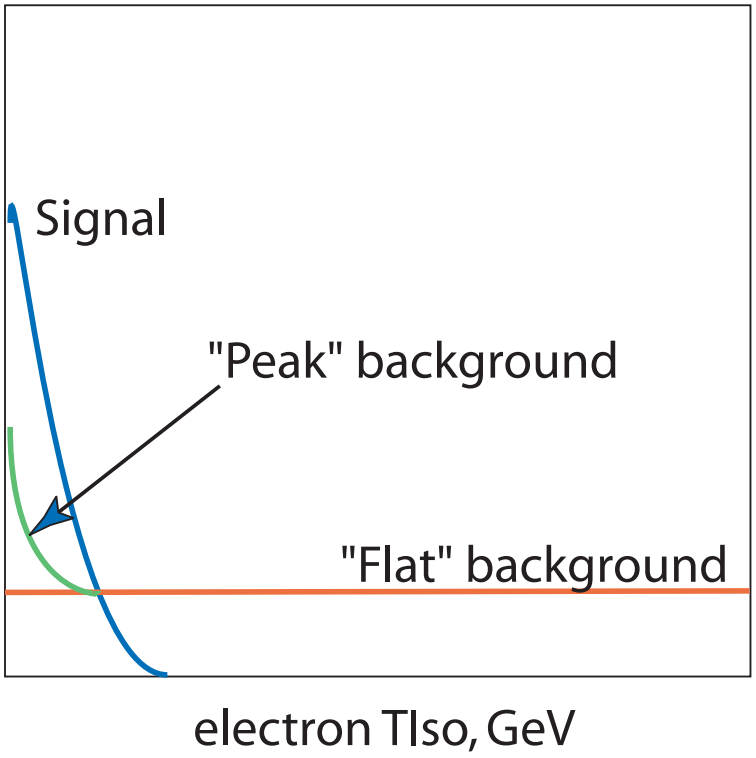
- The disagreement indicates that:
  - Backgrounds were determined incorrectly;
  - There is a difference between data and MC that we are not aware of;
  - Discrepancy is especially large for softer taus.
- Strategy:
  - Take as large sample as possible – drop “good run”.
  - Drop ET cut on tau – this will bring us to the most difficult region;
  - Try to understand backgrounds;
  - With known backgrounds try to isolate good taus and find what’s wrong with MC.

Heavy Flavor: bb-bar



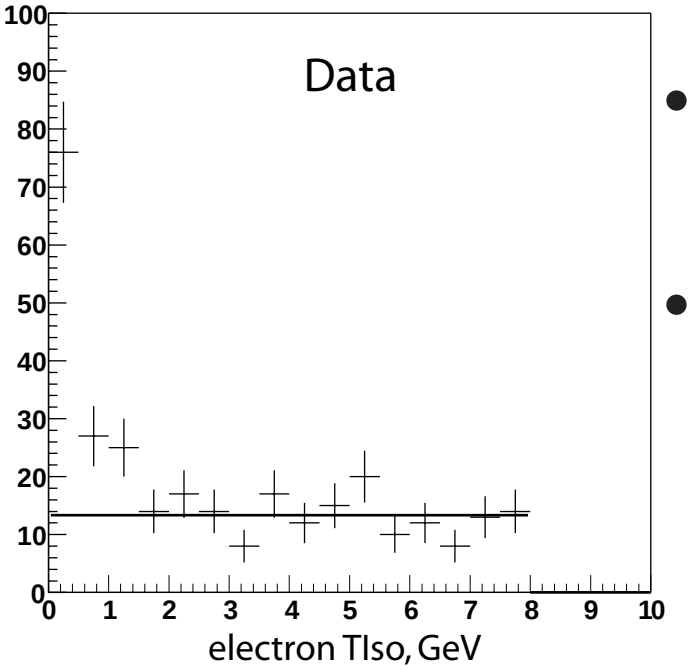
- Contribution is quite large
- Shape of the backgrounds is very different and not described by standard fake rates (those are based on light quarks)
- Circumstantial evidence:
  - Slight changes in electron cuts change tau-candidate multiplicity in data a lot!
- Conclusion: need a better background estimation technique!

Backgrounds - New Approach

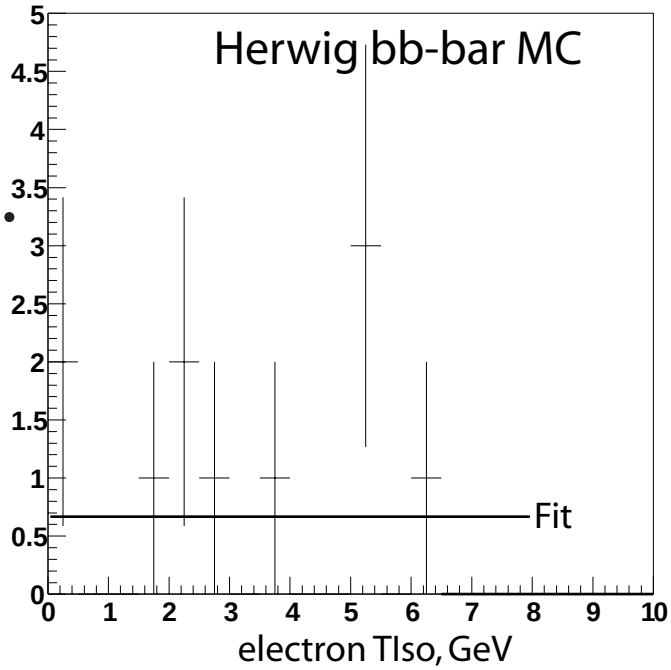


- A little phenomenology:
  - When looking for something inside jets (e.g. a photon faked by a jet - backgrounds from jet remnants are often flat as a function of isolation).
  - Electrons from W's and Z's are typically highly isolated
- Two types of backgrounds:
  - "Flat" as a function of electron Tracking Iso - QCD, heavy flavor
  - "Peak" – W+jets and such

Are They Really “Flat”+”peak”?

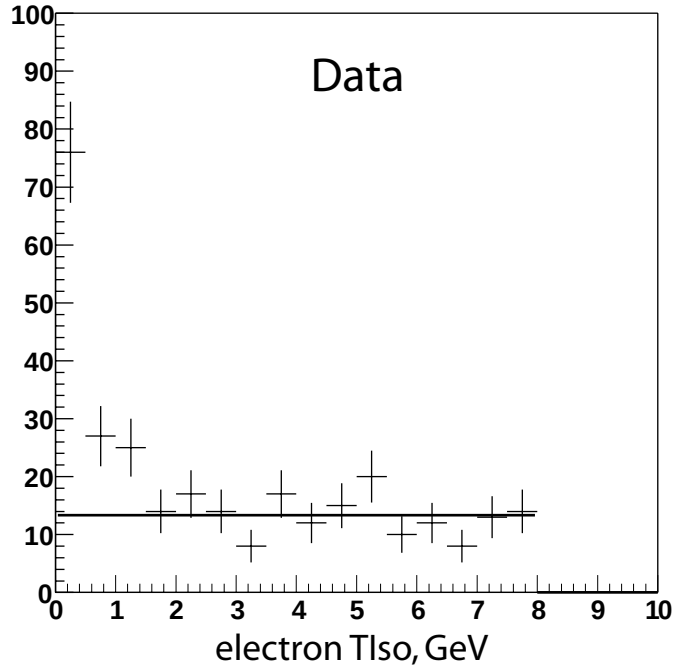


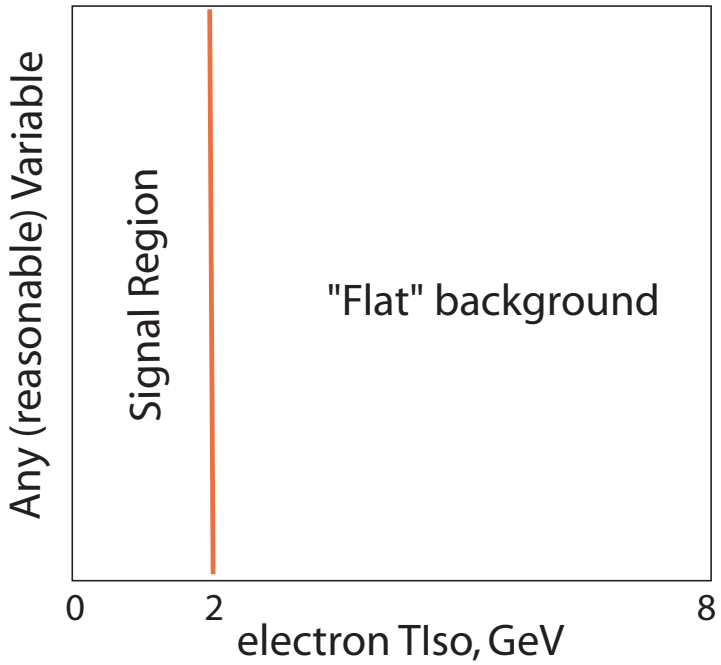
- “Peaks” are pretty obvious.
- “Flats” are less obvious, but verifiable.



  - Look directly at the data – left plot.
  - Heavy Flavor may seem not obviously flat (electron there is “real” from the semi-leptonic decays) – right plot, Herwig MC for bb-bar.

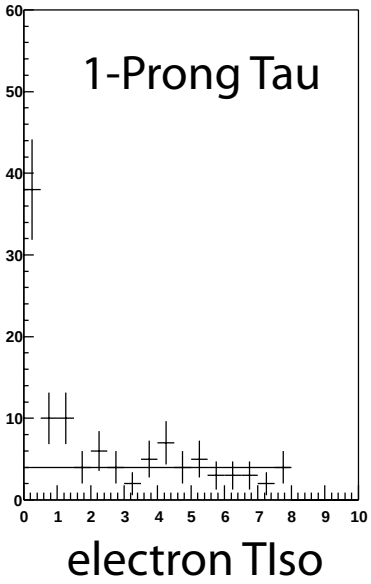
Removal of “Flat” Backgrounds

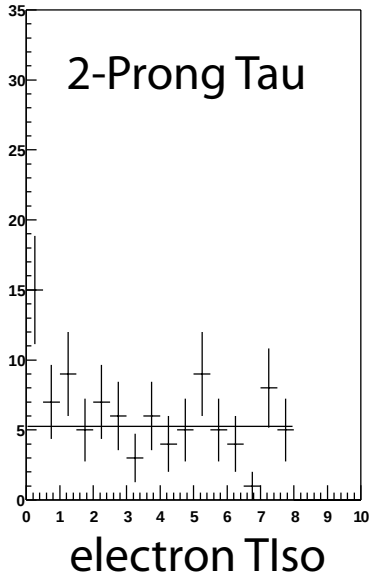


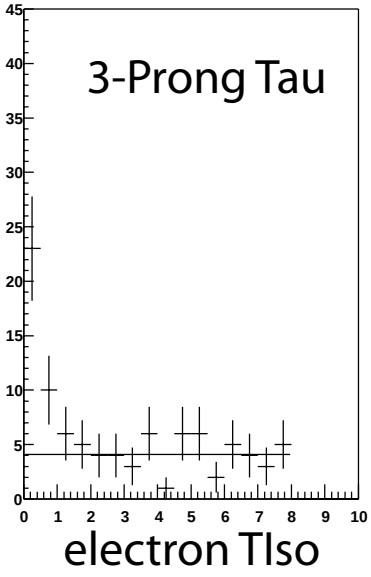


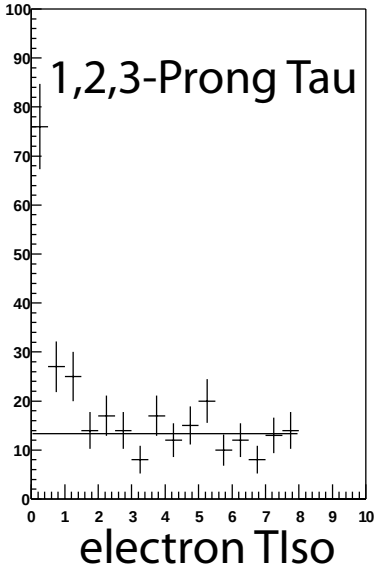
- For the number of “flat” background events in the signal region – fit “flats” level in (2:8) and extrapolate into (0:2).
- Extend this technique to spectra of other variables (e.g. mass spectrum of background events)– measure the spectrum in the “flat” region, divide by 3 ((8-2)/(2-0)), and subtract from data in signal region.

Data: Removal of “Flats”



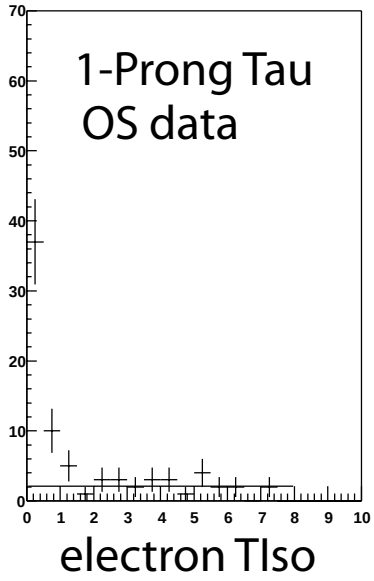


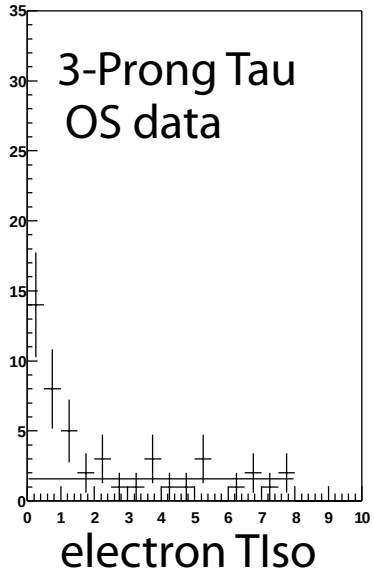


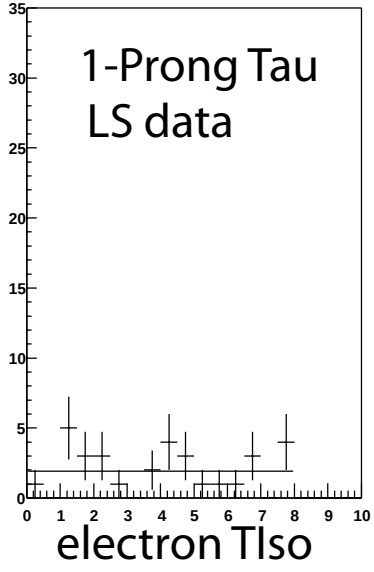


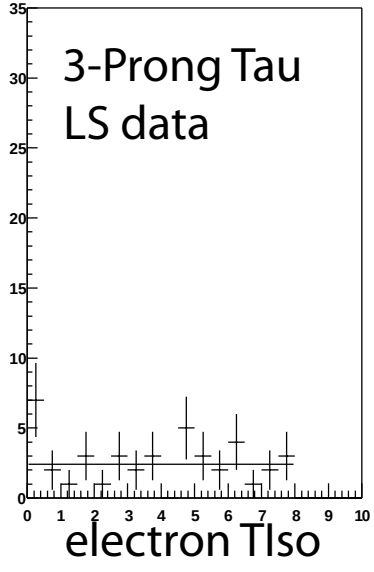
- Calculate “flat” background contribution for each bin in tau candidate track multiplicity.
- Take care of the “peaking” backgrounds later

Removal of “Peaks” –Prongs 1, 3



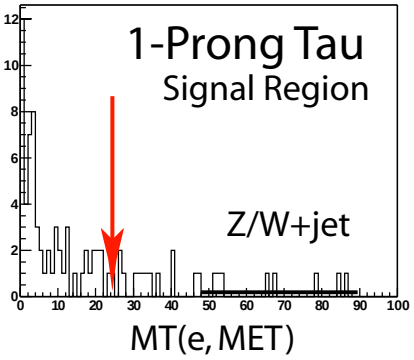


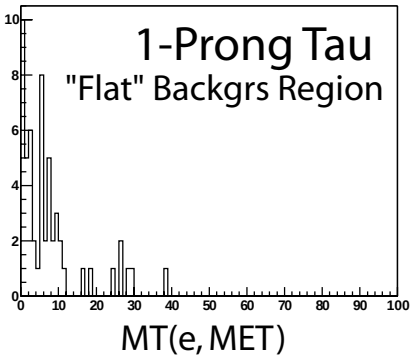


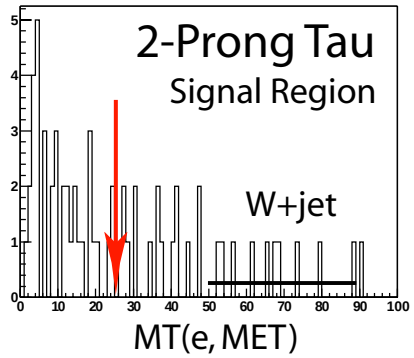


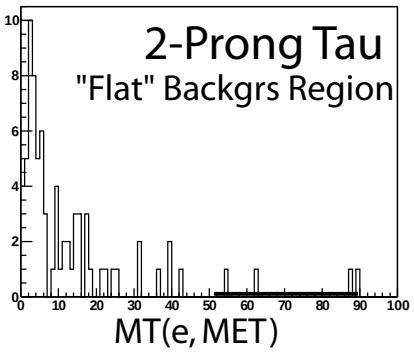
- Simple way:
  - Look at LS data. This is 100% backgrounds. Get access over flat background. These are “peaks” in LS data.
  - Assume W+Jet is charge-blind and that number of “peaks” in OS is the same (and vary it to estimate systematics)
- Or get ratio from data!

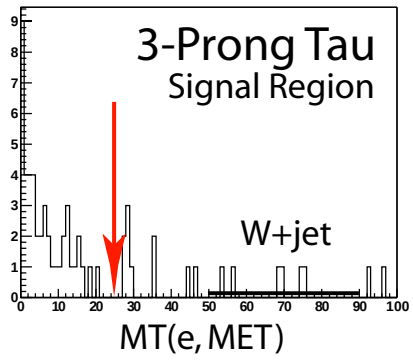
Removal of “Peaks” –Prong 2

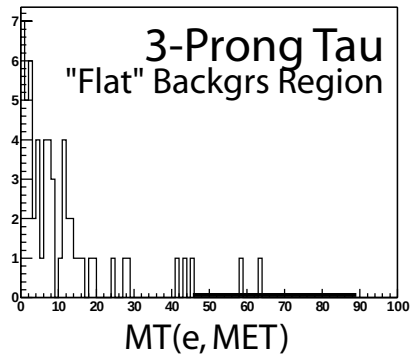






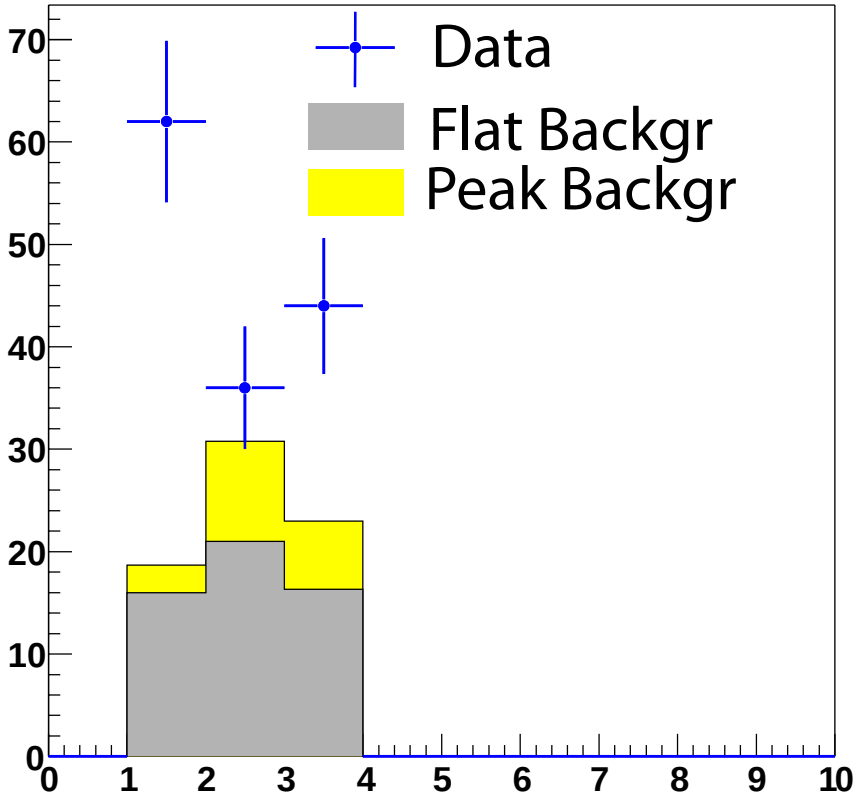






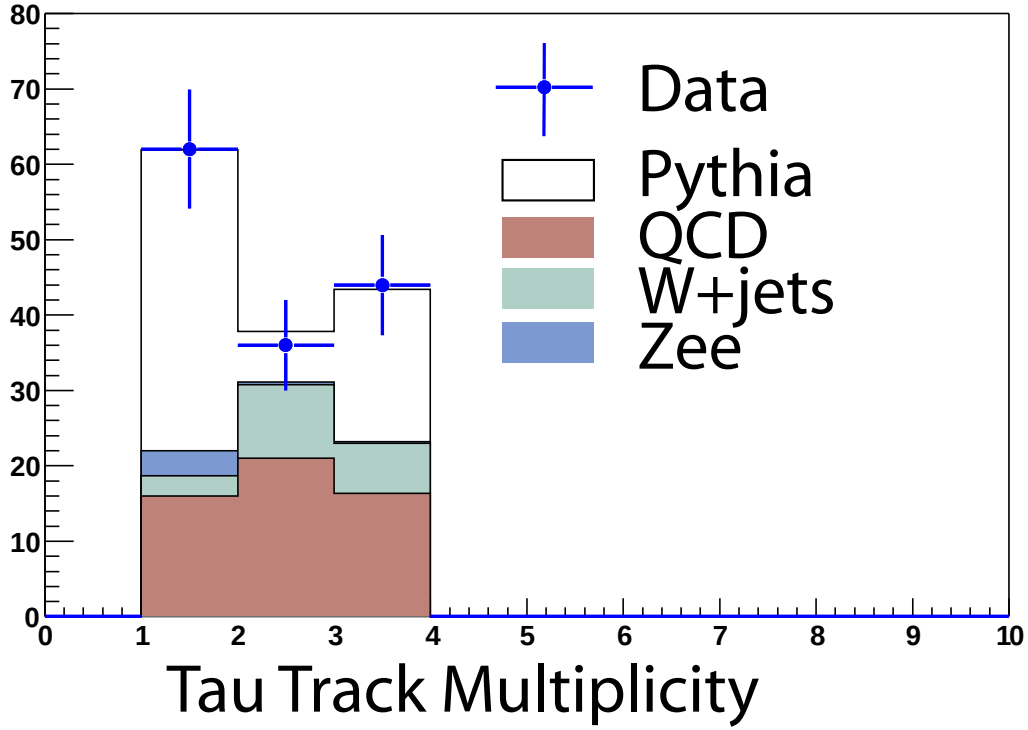
- There are no OS or LS here (tau charge is 0, +/-2)
- Simple way – just ignore 2-Prong data and not use it.
- Better way – get relative ratio of 2 and 3-Prongs from data (look where transverse mass of e and MET is large – these are W+jets). Use 3-Prong “peaks”, scale them.
- One can also plot LS/OS for 1,3 Prong bins to extract LS/OS ratio for “peaking” backgrounds.

Backgrounds



- Sum “flat” (QCD) and “peak” (Wjet/…) and plot multiplicity of tau candidates.
  - “flat” backgrounds do not use any OS/LS factors.
  - “peaking” backgrounds are relatively small and one can vary OS/LS ratio without large effect on the cross-section measurement.
- Data is around 100 pb^{-1} pre-January shutdown (no good Run selections)
- Ready to compare to MC.

Tau Multiplicity – Fit to MC



- First, add Z→ee background (it's not factorized out b/c it's heavily OS) using MC.
- Fit to MC.

- Excellent agreement!
- σ= (380±90)*Ł/L (~270 pb – we don't know Ł precisely)
- Next step – vary cuts and see if this holds.

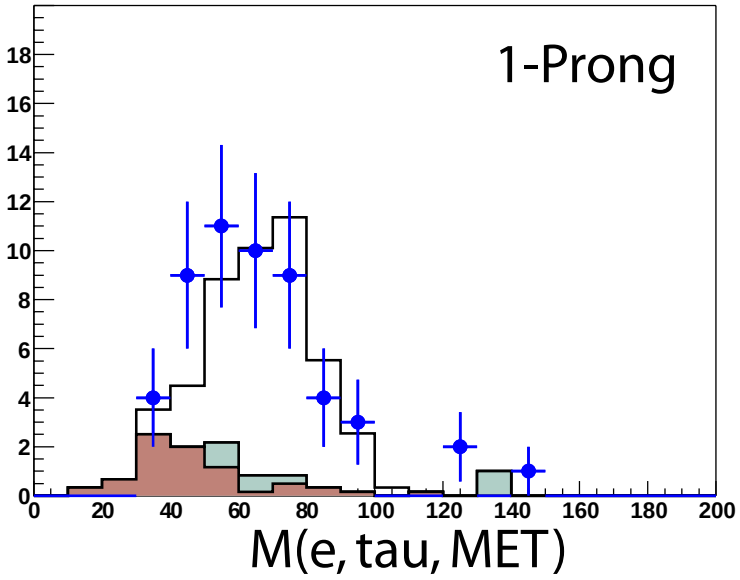
Consistency Checks

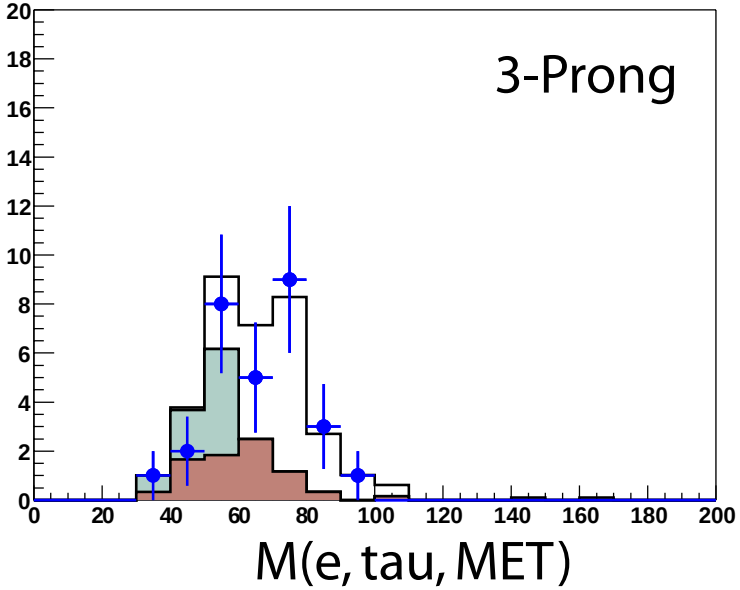
- Vary initial tau ET cut, re-apply full procedure and re-measure σ*L/Ł:

Min “tau” ET	σ*L/Ł
5	380±90
15	390±90
20	350±90
25	335±90
Stop conversion removal	360±100

- Looks good, but there maybe a trend (small now)

Mass Spectrum





- Use same technique for "Effective Mass" (invariant mass of e, tau, MET).
- Combined Fit of 1 and 3 Prong tau mass spectra:

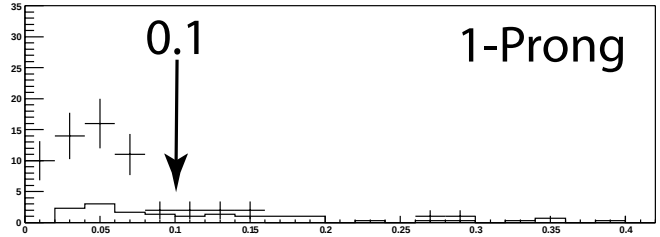
  $\sigma^{*}L/Ł=370\pm80$ pb
- Some (small) difference in the shape of 1-Prong mass.

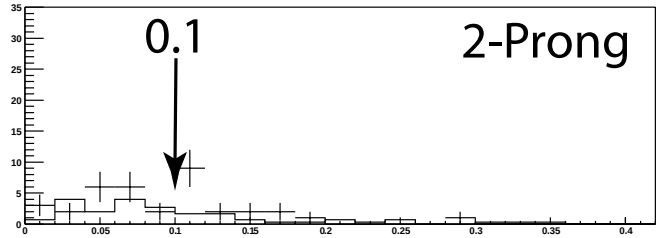
* *Zee background is not included yet*

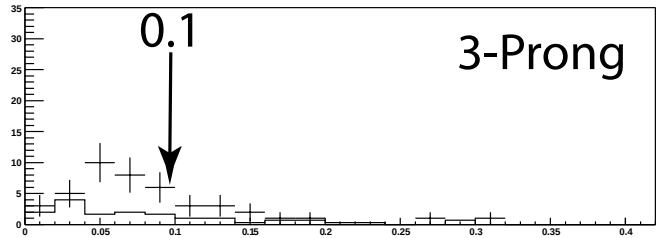
New Found Problems – part 1

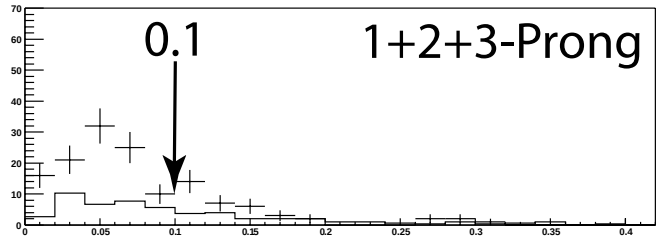
- The trend appears to be due to inefficiency of $\pi 0$ reconstruction:
  - Several events at low mass have large unaccounted EM energy.
  - Correction will make data agree with MC better (events with a lost $\pi 0$ from lower mass will migrate to higher mass).
- More pronounced for 1-Prong data (in 3-Prongs more ET is carried by charged tracks?)

New Found Problems – part II



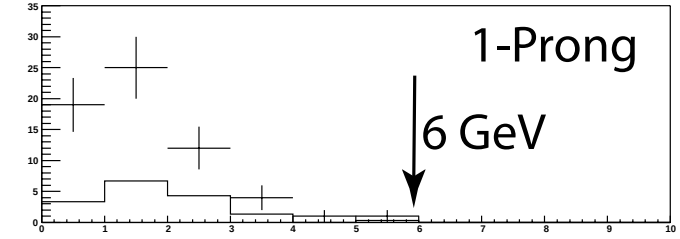


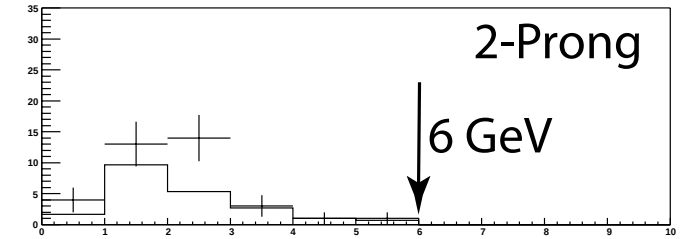


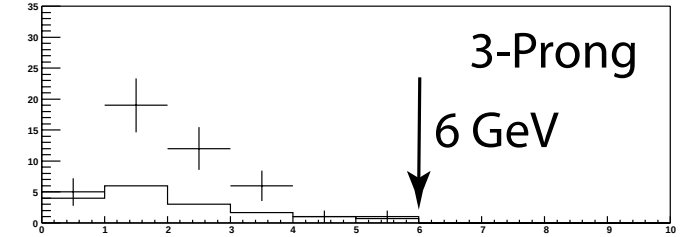


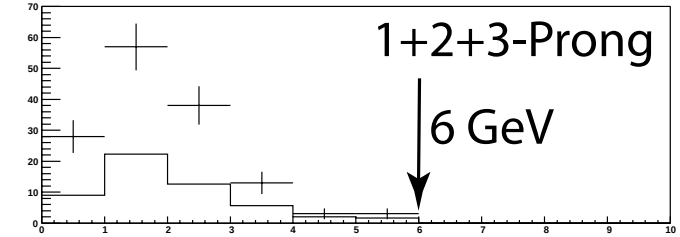
- Previously, we used a cut CaloIso(0.4)$_\tau$/CaloET$_\tau$<0.1
- Use our background subtraction technique and look at this variable!
- This cut is very tight! MC does not reproduce it! Larger effect for 3-Prong taus.
  - Simple solution – remove this cut
  - Long term – need leakage correction, requires significant work but worth the time

Tau Isolation









- For the time being, we chose the easiest fix to minimize differences between Data and MC by effectively removing this cut.
- Switch to absolute isolation of 6 GeV (~no cut at all)

Baseline Cuts

Electron (fiducial)	Comments
ET>10, PT>8; |d0|<0.2	
HadEm<0.055+0.0045*E; Lshr<0.2	
CES: |ΔZ|<3; –1.5<Q*ΔX<3, χ^2_Z<10	
EoP<2 for ET>50	
Track Absolute Isolation in 0.4 TIso<2 GeV	Was relative 0.2
Calorimeter Isolation – none (to avoid bias in TIso extrapolations)	Was 3 GeV
Tau (fiducial)	
Seed track PT>6; |η|<1	
ET>6 (10, 15, 20) GeV	Lower backgrounds at higher PT
Calo Iso < 6 GeV	Was relative 0.1 – **problem**
M(trk+π0)<1.8; Electron removal ξ>0.1	
No tracks PT>1, No π0 PT>0.5 in iso cone	
Event Topology	
|PT(e)+PT(MET)|>25	
MT(e, MET)<25 (15, 10?) GeV	Controls “peaking” backgrounds

Summary

- Looks like we finally got things under control!
- New baseline cuts are mostly defined:
  - Still want to choose a way to minimize even further the effect of OS=LS assumption
    - Tighter MT cut
    - Extract ratio of OS to LS from high MT region
    - Higher tau PT threshold
- Need to decide what to do with $\pi 0$ reconstruction inefficiency:
  - Leave as it is
  - Apply some quick fix (add a $\pi 0$ by hand if it's clearly missing)
  - Improve efficiency
- Will document things as a CDF note.
- Re-run analysis on the final sample.